Space Weather Technical Forecast

Issued on Thursday, 21 September 2023 at 01:15 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of further G1 minor geomagnetic storms from late Day 2 (22 Sep) onwards due to HSS and CME effects. Isolated R1-R2 Minor/Moderate Radio Blackouts likely throughout. Electron Fluence likely exceeding the Active threshold on Day 1 (21 Sep).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the past 24 hours, with the peak M-class flare reaching M8.1 at 20/1419 UTC. This flare associated with AR3435. AR3435, in the northeast, is the largest sunspot region and shows some minor reorganisation in its magnetic configuration, by reforming a small delta spot on the southern edge. AR3438 just to the west of this is also relatively unchanged. This area was originally part of AR3435, but has since calved-off. AR3436 and AR3437 in the northwest and southwest respectively are the next largest regions, and AR3436 has displayed some separation of its intermediate spots recently. The remaining regions are relatively unchanged with little activity.

A CME from an M-class flare that departed the Sun towards the southeast on 19 Sep. may give a glancing blow to Earth early on Day 3 (23 Sep). A second CME associated with the M-flare mentioned above also departed the Sun towards the southeast, and is undergoing analysis for any Earth-directed component.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by DSCOVR/ACE at L1, showed a steady decline over the past 24hrs, from an initial elevated peak around 560km/s at the start of the period, down to slightly elevated around 450km/s currently. The solar wind density was below average. The IMF was at weak to moderate levels with a peak around 11nT for an hour or two at 20/0600 UTC. The north-south component (Bz) remained at weak and variable levels, ranging from -4/+4nT. The phi angle was predominantly positive (Away from the Sun), but since around 20/1800 UTC has become negative (towards the Sun), albeit variable at times. Geomagnetic activity was at Quiet to Active levels (Kp2-4).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux was at background levels. GOES16 high energy (greater than 2MeV) electron flux was initially just below the high threshold, remaining at moderate to low levels until after 20/1300 UTC, when it moved above the high threshold and remained there until 20/2000 UTC. It has since dropped back to moderate levels. The associated 24-hour fluence was below the Active threshold, with a rising trend and 7.16e7 integrated pfu observed at 21/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be at Low to Moderate levels, with further isolated M-class flares likely, particularly from AR3435.

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Solar Wind / Geomagnetic Activity: Solar winds likely at slightly elevated levels and easing as Earth comes out of high speed stream (HSS) and CME influences from past couple of days. Another HSS influence is likely during the period, arriving late Day 2 into Day 3 (22-23 Sep) as CH51/- comes into effect.

Generally Quiet to Unsettled (Kp2-3) conditions expected at first, perhaps with a slight chance for Active intervals (Kp4). From late Day 2/early Day 3 (22-23 Sep) onwards, Active levels (Kp4) of geomagnetic activity look likely due to the onset of CH51/- HSS and the possible influence of a glancing CME, with a chance of G1 Minor Storm intervals (Kp5).

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is expected to remain at Background levels, with a daily slight chance of an enhancement should any larger flares occur. High energy (greater than 2 MeV) electron flux is likely to be mostly at moderate to high levels. Overall, the 24-hour fluence is possible to rise above the Active threshold on Day 1 (21 Sep), and potentially remain elevated though with reducing confidence later in the period.

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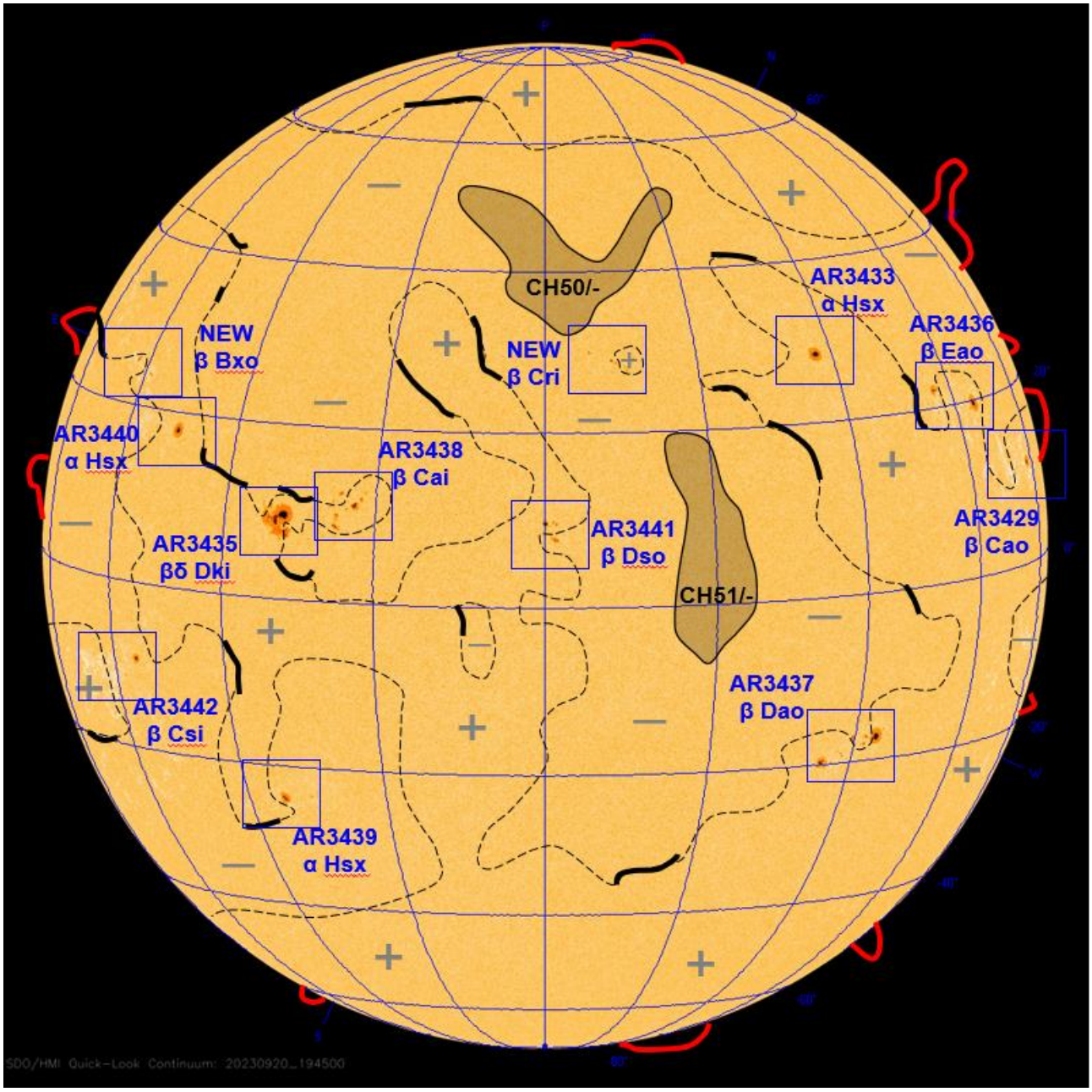
Figure 1. Solar Analysis Valid 20/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The recent CME that influenced the near Earth environment looks to be easing, along with any coronal hole HSS influence that may have come from CH52/+. As such, geomagnetic activity is expected to be low on Day 1 (21 Sep). The next HSS that looks likely to connect with the Earth will most probably be from CH51/-, which is currently situated just west of centre disc. This should give an increase in solar winds from late Day 2 (22 Sep) or early Day 3 (23 Sep) onwards. Persistence data suggests that the current Enlil signal for Elevated wind speeds looks slightly excessive, so confidence in the forecast solar wind conditions is lower than average. As well as this, the negative polarity of the coronal hole isn't conducive for high geomagnetic activity at this time of year, and so Unsettled to Active levels (Kp3-4) looks most likely from late Day 2/early Day 3 onwards. A CME from an M-class flare that departed the sun towards the southeast on 19 Sep has been analysed and modelling from Enlil shows that it may give a glancing blow to Earth late on Day 2 or early on Day 3 (22-23 Sep), which combined with the HSS influence gives a chance for G1 Minor Storm intervals (Kp5). The CME from the M8.1 flare on 20 Sep is awaiting analysis as to any Earth directed impacts.

In summary, Day 1 and most of Day 2 (21-22 Sep) expected to see Quiet to Unsettled levels of geomagnetic activity. Late on Day 2/early on Day 3 (22-23 Sep) the influence of CH51/- looks most likely to come into effect, which combined with a possible CME glance gives likely Unsettled to Active levels for Days 3-4 (23-24 Sep), with a chance for G1 Minor Storm intervals.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	30	40	20
Strong	G3	No	1	5	5	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
20/0315	Partial	Flare	NE (AR3435)	515	23 Sep	Glancing blow at worst.

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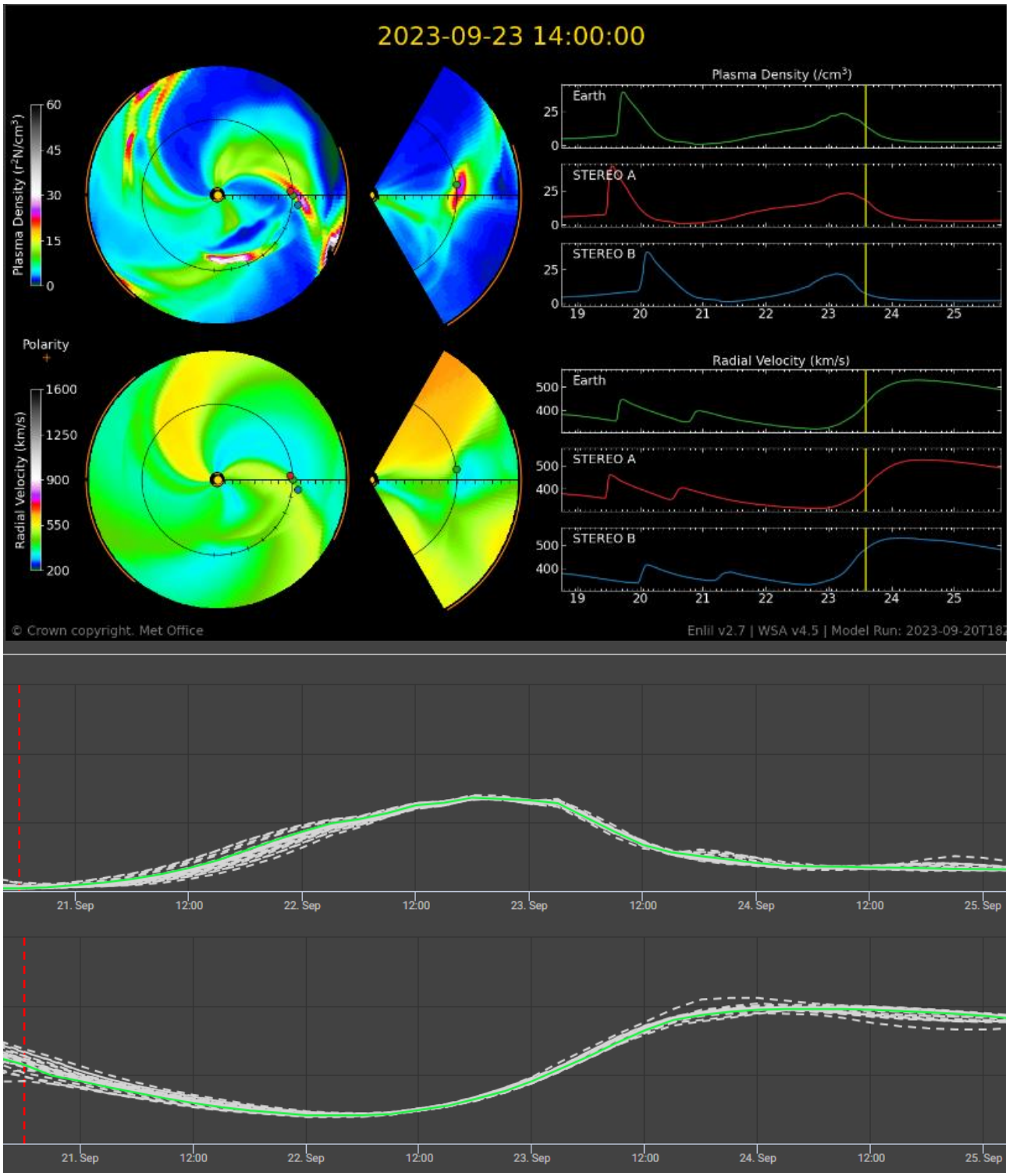
Figure 2: MOSWOC Enlil and Ensemble data. Arrival of coronal hole fast wind shown early 23 Sep. Possible weak glance CME influence generally lost in the fast wind, but subtle signal indicated on 23 Sep.



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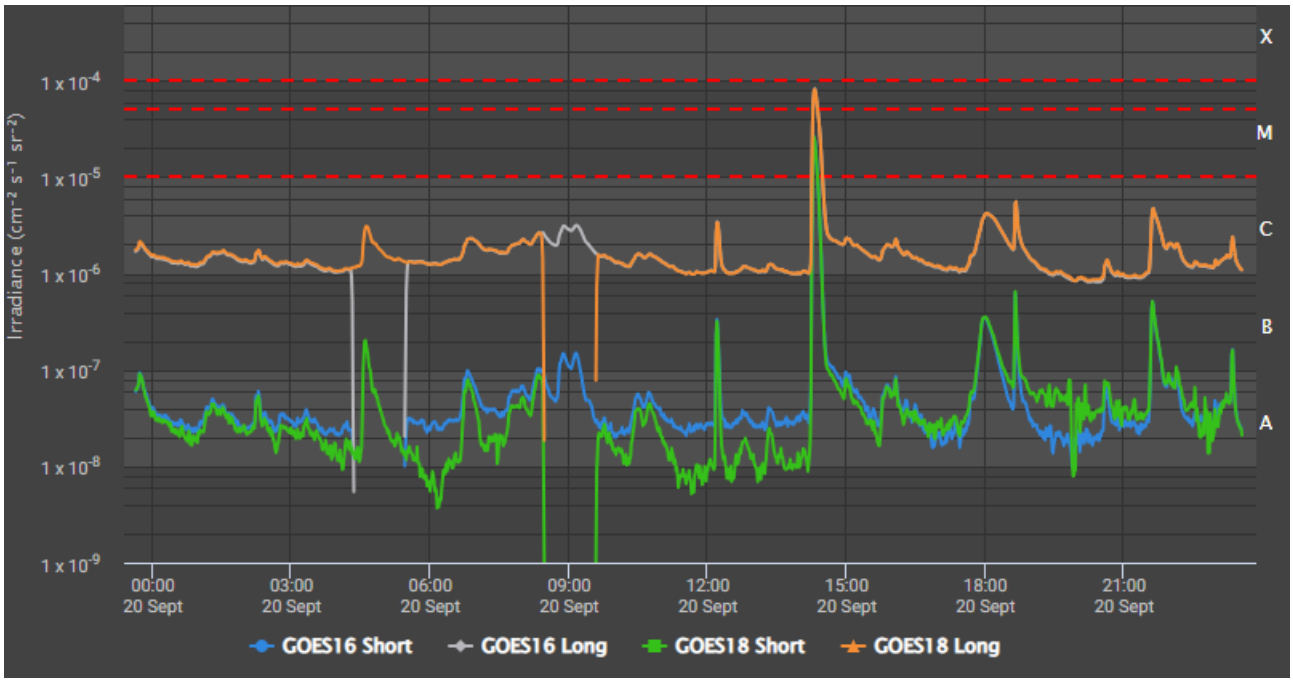
Radio Blackouts - X-Ray Flares:
In total on the visible disc twelve active regions are evident, with two unnumbered. The largest and most active region on the disk is AR3435 (Dki/Beta-Delta) in the northeast, and was responsible for the M8.1 flare peaking at 20/1419 UTC. Continuing magnetic complexity visible with a north-south magnetic alignment likely aiding shear instability, as well as a small delta spot on the southern edge. AR3438 (Cai/Beta) just to the west is also relatively unchanged. This area was originally part of AR3435, but has since calved-off. AR3436 (Eao/Beta) and AR3437 (Dao/Beta) in the northwest and southwest respectively are the next largest regions, with AR3436 displaying some minor changes as some intermediate spots begin to fade. The remaining regions are relatively unchanged with little activity. Solar activity is expected to remain at Low to Moderate levels. There is a continued chance of further M-class flares, with the greatest risk continuing to come from AR3435 in the northeast, and perhaps also from AR3438.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	60	60	60
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES 16 and 18 X-ray flux. M8.1 flare shown at 20/1419 originated from sunspot region AR3435.



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Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux observed by GOES16 is expected to persist at Background levels, but with a daily slight chance of flux levels rising in response to any significant flaring.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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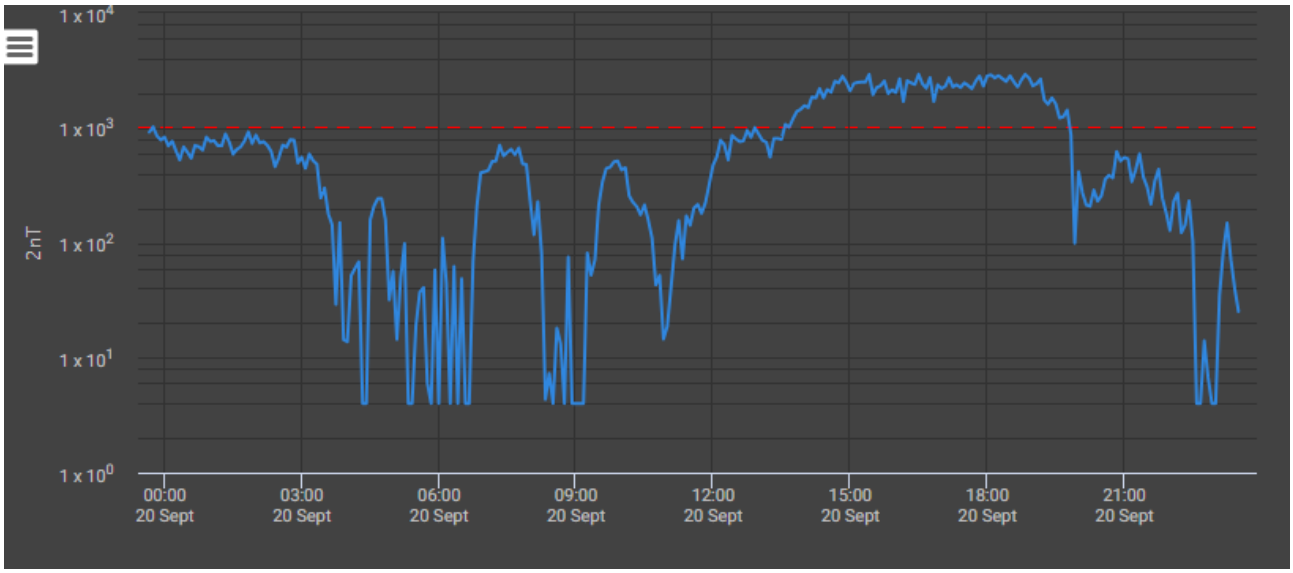
High Energy Electrons Event (≥ 2MeV):

High energy (greater than 2MeV) electron flux levels are likely to breach the 1000pfu high threshold. An uncertain forecast, with recent CME arrivals and elevated solar winds likely to have seen a build up of change within the belts and the current easing of solar winds and reduction of geomagnetic activity expected to see flux levels increasingly rise above the High threshold. Some reduction likely in the near term however, both diurnally but also given the potential for further geomagnetic activity later in the period. The 24-hour fluence is currently below the Active threshold but on a rising trend, with current MOSWOC REFM output forecast providing reasonable guidance, with an increased risk of breaching the active threshold on Day 1 (21 Sep). Forecast remains lower confidence however given uncertainties beyond this.

GEO Electron Environment Probability (Exceedance)	Level ($cm^{-2}\ sr^{-1}\ day^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	60	60	50	40
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 4: GOES 16 Electron flux and REFM model showing observed, forecast and recurrance electron fluence.



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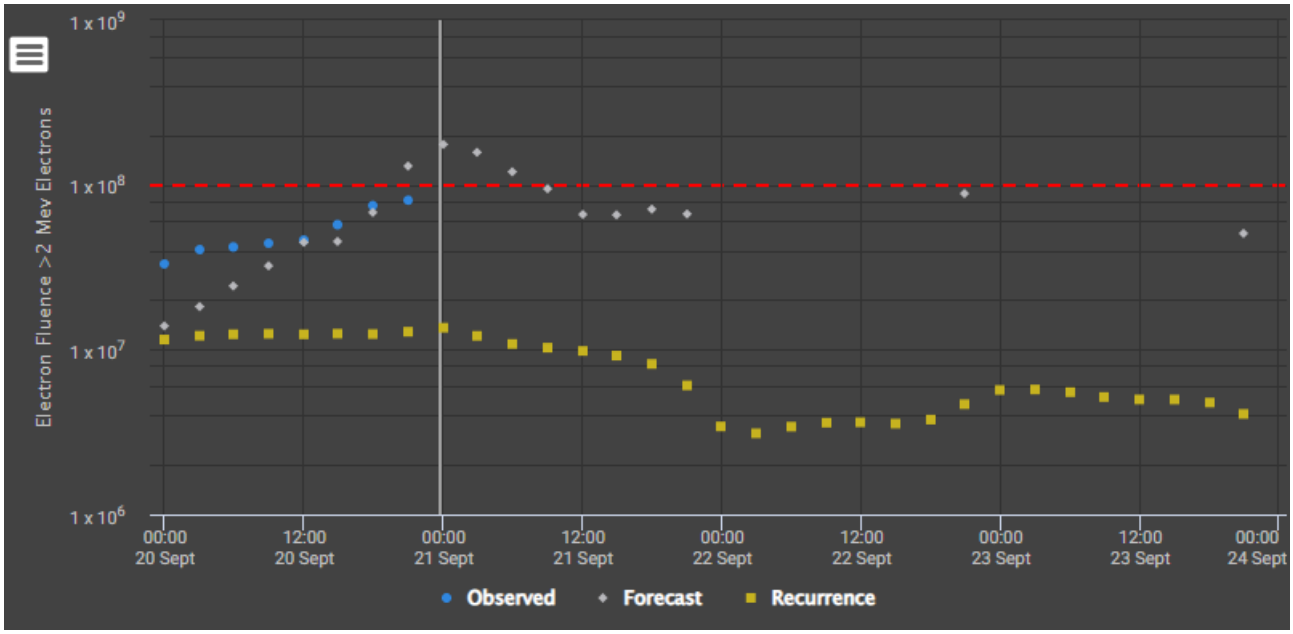

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